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March, 1968 #315-68

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This paper has been submitted for publication in Behavioral Science.

Donald Marquis is Professor of Organizational Psychology and Management, and Joseph Reitz is a Pittsburgh Plate Glass Fellow and a doctoral candidate. The expenses of the research were met by a grant from the National Aeronautics and Space Administration.

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Abstract

Experimental gambling situations were used to test (1) the effects of uncertainty on individuals' willingness to take risk and (2) the effects of group discussion under conditions of positive, zero, and negative expected value. In all three experimental conditions individuals risked less money under uncertainty. The comparison of group with individual decisions showed results consistent with a model which proposes that group discussion enhances prior expected values and also results in a risk bias effect when uncertainty is present.

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We can classify probabilistic situations facing a decision maker according to the type of information he has concerning his decision alternatives. Pure risk describes the situation in which the decision maker knows all possible outcomes and can assign definite probabilities to each outcome. Uncertainty describes the situation in which the decision maker is unable to assign definite values to outcomes and/or is unable to assign definite probabilities to each outcome. Obviously there can be degrees of uncertainty according to how closely the probabilistic outcomes of a decision choice can be defined.

One might expect a decision maker to take an attitude toward a pure risk situation different from his attitude toward an uncertain, but otherwise equivalent, situation.

> "Two alternatives may each possess an expected return of 20 percent, yet the possible returns of one may range from -40 to +80 percent while the returns of the other range from 10 to 30 percent. In few cases will these two investments be considered equally desirable" (McFarlane and Horowitz, 1967).

Research on the effects of uncertainty on risk-taking has been limited. Chipman (1960) used two forms of a match game to test preferences between pure risk and uncertain alternatives. Subjects were confronted with two match boxes, each containing a combination of "heads" and "stems" totaling 100 pieces. One box was marked with the exact proportion of heads and stems, i.e., "60 heads and 40 stems." The other box was known only to contain 100 pieces of unknown proportions.

Individuals were allowed to draw a sample of 100 from the unknown box; the sample was rigged to be in the same proportion as the known box. They were then asked to draw one piece from either the known proportion box or the unknown but sampled box. The payoff was a win of 25 cents if a head was drawn, but a loss of 25 cents if a stem was drawn.

Chipman reported that subjects in general preferred to draw from the known proportion box if the ratio of heads to stems was 50-50 or greater. However, when the known proportion was fewer heads than stems, the subjects preferred to draw from the uncertain box. For instance, when subjects were confronted with a box marked "40 heads and 60 stems" and an unmarked box from which a sample of 4 heads and 6 stems were drawn, 74 percent of the choices were for the uncertain box.

Raiffa (1961) asked subjects how much they would pay to play a game in which they won $100 if they successfully predicted the color of a ball drawn from an urn. Urn #1 was known to contain 50 black and 50 red balls. Urn #2 contained 100 balls, with the proportion of red to black being unknown. The majority of subjects preferred to pay considerably more to draw from urn #1 than from urn #2. A typical response was a bid of $35 for urn #1 and $5 for urn #2.

There is, then, some evidence for an effect of uncertainty on risk-taking. Raiffa and Chipman both found situations in which pure risk choices were preferred to uncertain choices. But Chipman also found uncertainty preferred to pure risk when the expected value of the gamble was negative.

INDIVIDUAL DECISIONS

The research reported in this paper first tests the effects of uncertainty on individuals' willingness to take risk in gambling situations. The hypotheses tested grew out of two theses with Marquis. Hinds (1962) found that individuals were more risky after group discussion of life-situation dilemmas, but did not show the effect on gambling-type items. Hubbard (1963) noted that the life situation items could be classified as uncertain, whereas the gambling items used by Hinds should be classified as pure risk, since the stake, the probability of winning, and the prize were specified exactly. Hubbard proposed that it is the reduction of uncertainty which leads individuals to make riskier decisions after group discussion, and that when there is uncertainty in a problem, individuals are less willing to take risk. The results of Hubbard's initial test of this proposed effect and of follow-up experiments by Reitz are reported in this paper.

The hypotheses to be tested are: (1) Uncertainty reduces the propensity of individuals to take risk. Risk is operationally defined as the amount of money an individual is willing to bet in a given situation. (2) The effect of uncertainty in reducing the amount of risk taken will increase as uncertainty is increased.

Experimental Methods

Hubbard's subjects were 34 first-year male graduate students of industrial management at MIT. Reitz's population included male students from both MIT and Northeastern University.

Hubbard used a set of gambling problems. Each problem had nine alternatives, from which the subject was instructed to choose one. Each alternative listed the stake involved (from $.06 to 1.18), the chance of winning, and the prize. The expected value of each alternative bet was zero on each problem in Hubbard's set. (Expected value = stake minus chance of winning x prize).

There were three basic types of problem in Hubbard's set: pure risk, small uncertainty, and large uncertainty. For the pure risk problems, the stake, chance of winning, and prize for each of the nine alternatives was given exactly. One such alternative was given as follows:

Stake	Chances of Winning	Prize
$.51	3 out of 10	$1.70

Eight other alternatives were given in that problem, all with the same chance of winning, but with stakes varied between $.16 and $.70 and with prizes varied such that the expected value was zero.

For the uncertain problems, either the stake, the chance of winning, or the prize was indicated only by a given range. Typical alternatives on uncertain problems were:

Type of Problem	Stake	Chance of Winning	Prize
Uncertain Stake	$.18 to $.86	3 out of 10	$1.72
Uncertain Probability	$.51	Between 1 out of 10 and 5 out of 10	$1.70
Uncertain Prize	$.50	3 out of 10	$.16 to $3.16

Exhibit I

A typical problem involving uncertainty and risk

Check the one bet you prefer to play from those listed below.

Check One	Stake	Chances of Winning	Prize
_____	$.06 to .28	3 out of 10	$.57
_____	$.08 to .43	3 out of 10	.85
_____	.12 to .59	3 out of 10	1.18
_____	.14 to .71	3 out of 10	1.42
_____	.18 to .86	3 out of 10	1.72
_____	.19 to .97	3 out of 10	1.93
_____	.21 to 1.04	3 out of 10	2.08
_____	.22 to 1.12	3 out of 10	2.23
_____	.23 to 1.18	3 out of 10	2.35

The following four types of problems were given to each subject

Type	Stake	Chances of Winning	Prize
Pure Risk	Certain	Certain	Certain
Small Uncertain Stake	Uncertain (±.2xprize)	Certain	Certain
Small Uncertain Probability	Certain	Uncertain (±.2)	Certain
Large Uncertain Prize	Certain	Certain	Uncertain (±.9 x Prize)

Hubbard instructed his subjects to play as if each had $5 in his pocket. This was intended to assure a reasonably uniform assumption of wealth and to create some concern over the possibility of losing the stake involved. After presenting a sample problem, printed instructions told subjects to consider the problems and indicate which alternative in each one they would prefer to play. The risk preferences were static choices in that bets were not actually played. Individuals had no opportunity to base their selections on outcomes of previous situations.

Although Reitz's instrument and methods were essentially the same, there were these significant differences:

1. Reitz paid each individual $3 to participate in the experiment, and told them that they would play their bets for keeps.

2. In one experiment 29 individuals were presented with five problems, in each of which all alternatives had a positive expected value of 10 percent (as opposed to zero expected value in Hubbard's study). This fact was made explicit to the subjects, both orally and in writing, before they indicated their preferences.

3. In a second experiment 38 individuals were presented with five problems with <u>negative</u> expected values of -25 percent. Again, this fact was explained to the subjects, both orally and in writing, before the experiment.

Since the findings are reported together, these differences should be summarized:

Exhibit II

Experiment	A(N=34)	B(N=29)	C(N=38)
Expected value of problems	Zero	+10% stake	-25% stake
Type of decision	Advisory	Played for keeps	Played for keeps

Results

Hypothesis 1: Uncertainty reduces the willingness of individuals to take risk. For each individual, the amount bet on the pure risk items was compared with the amount bet on the uncertain items. In each of the three experiments individuals tended to risk more money on items where there was no uncertainty (pure risk) than on uncertain items. The hypothesis was supported for all three conditions of expected value: zero, positive, and negative, as shown in Table 1.

TABLE 1

Pure Risk Problems vs. All Uncertain Problems

	Group A- Zero Expected Value Problems	Group B- Positive Expected Value Problems	Group C- Negative Expected Value Problems
Mean bet on Pure Risk Items	55¢	65¢	50¢
Mean bet on All Uncertain Items	40¢	55¢	45¢
Level of Significance	$p < .005$*	$p < .05^{+}$	$p < .05^{+}$

Hypothesis 2: The effects of uncertainty increase as uncertainty is increased. Uncertain problems differed in the range of values of the probabilistic outcomes. Large uncertainty problems had ranged of uncertainty at least twice as large as that of small uncertainty problems. For instance, the expected value of a large uncertainty problem for Experiment B ranged from -45% to +65% of the stake. The expected value of the comparable small uncertainty problem ranged from -17.5% to +37.5% of the stake.

TABLE 2

Pure Risk Problems vs. Problems Involving a Small Degree of Uncertainty

	Group A- Zero Expected Value Problems	Group B- Positive Expected Value Problems	Group C- Negative Expected Value Problems
Mean bet on Pure Risk Items	55¢	65¢	50¢
Mean bet on Small Uncertainty Items	41¢	58¢	47¢
Level of Significance	$p < .005$*	$.10 < p < .15^{+}$	$.05 < p < .10^{+}$

TABLE 3

Problems Involving a Small Degree of Uncertainty vs. Problems Involving a Large Degree of Uncertainty

	Group A- Zero Expected Value	Group B- Positive Expected Value	Group C- Negative Expected Value
Mean bet on Small Uncertainty Items	41¢	58¢	47¢
Mean bet on Large Uncertainty Items	39¢	52¢	44¢
Level of Significance	$.05 < p < .10$*	$p = .05^{+}$	$p < .05^{+}$

*1-tail p by Wilcoxon Matched Pairs Signed Ranks Test (Hubbard's data meaningful only on ordinal scale)

+1-tail p by T-test for dependent samples

Tables 2 and 3 reveal that in each case large degrees of uncertainty are associated with lower bets, although with varying levels of significance. Support for the hypothesis is clear under each condition of expected value.

Discussion

The findings indicate that uncertainty has a systematic effect on an individual's willingness to take risk. In all three conditions of positive, zero, and negative expected value, individuals tended to risk less money on uncertain questions. Furthermore, individuals bet less when there is a large degree of uncertainty, than when there is only small uncertainty.

These findings, while not surprising in the experiment with positive expected value, are less obvious when expected values are zero, and are contrary to the implications of Chipman's match box experiment with negative expected values. It should be pointed out that Chipman's subjects were paid after each decision. The outcomes of previous decisions could thus have influenced subsequent decisions. In the experiments reported here, no bets were played until all decisions had been made.

GROUP DECISIONS

Since the report of Stoner's (1961) finding (Marquis, 1962) that after group discussion individuals are more risky than before, a deluge of about 40 research reports has followed. Although most of the reports have confirmed the tendency for groups to take greater risk than individuals, the explanation of this phenomenon has been less successful than the replication until recently (Marquis, 1968).

The most attractive explanation of the influence of group discussion on risk-taking is that offered and tested by Stoner (1967), viz., the clarification of outcome values. When the relative values favor the risky alternative, Stoner predicted and found that groups would make riskier decisions than individuals. When the relative values favor the cautious alternative, group decisions are more cautious than individuals.

Burns (1967) has presented an analytic model surprisingly successful at predicting the riskiness of group decisions. His model is based on prior individual decisions but has to include a risk bias factor, even when predicting the decision outcomes of group discussion which are more cautious

than individuals.

Hubbard first proposed in his thesis (1962) that the risk bias is limited to decisions involving uncertainty. He postulated that uncertainty reduces willingness to take risk, and that group discussion, reducing this uncertainty, results in group decisions with greater risk than individual decisions.

It therefore seems desirable to test the proposition that the shift resulting from group discussion can be predicted on the basis of outcome values and of uncertainty. The gambling items described earlier provide such an opportunity. Each item can be classified on two dimensions: the degree of uncertainty and expected values which are either zero, positive or negative.

Hypothesis: We propose that uncertainty in a decision problem will make groups tend toward riskier decisions than individuals, and that group discussion will at the same time result in decisions more consistent with relative outcome values. In the gambling-type items used, we expect the "forces" diagramed in Figure 1 to be at work in group decision processes.

Pure Risk Problems: No Uncertainty

Forces	Zero Expected Value	Positive Expected Value	Negative Expected Value
Maximize Expected Value	0	↑	↓
Reduce Effects of Uncertainty	0	0	0
Resultant	0	↑	↓

Uncertain Problems

Forces	Zero Expected Value	Positive Expected Value	Negative Expected Value
Maximize Expected Value	0	↑	↓
Reduce Effects of Uncertainty	↑	↑	↑
Resultant	↑	↑	? Whichever is stronger

Figure 1. Forces at Work in Group Decision-Making

Key: ↑ indicates tendency to increase risk

↓ indicates tendency to decrease risk

0 indicates no tendency to change

The following specific hypotheses are presented:

1. On problems with zero expected value and no uncertainty (pure risk), decisions following group discussion will not differ from average initial individual decisions.

2. On problems with negative expected value and no uncertainty (pure risk), group discussion will result in decisions less risky than initial individual decisions.

3. On problems with zero expected value involving uncertainty, group discussion will result in decisions more risky than initial individual decisions. On all problems with positive expected value, both pure risk and uncertain, group discussion will result in decisions more risky than initial individual decisions.

4. On uncertain, negative expected value problems the forces will be in opposition. The direction of shift will depend on the relative size of the two forces in opposition.

Experimental Methods

After indicating their individual decision preferences as described earlier in this paper, individuals were assigned to groups of three to seven members. They were instructed that the individual decisions were only to allow them to indicate an initial position, and that the crux of the experiment was to arrive at unanimous group decisions on the same problems. They were then instructed to discuss each problem and arrive at a unanimous group decision. The groups were informed that each member would himself play the bets unanimously selected by the group.

The group session usually lasted about 45 minutes, after which individuals were asked to record their final, personal preferences in private. Bets were then played off, using two decks of cards and simple probability distributions.

Results

Comparing the amounts bet by individuals on the pure risk question before group discussion with their decisions after group discussion, Table 4 reveals results consistent with those predicted.

TABLE 4

Comparison of Pre- and Post-Discussion Individual Risk Perferences on Pure Risk Problems

	Type of Problem		
	Zero Expected Value	Positive Expected Value	Negative Expected Value
Mean pre-discussion bet	55¢	65¢	50¢
Mean post-discussion bet	54¢	81¢	29¢
Level of Significance	N.S.*	$p < .01^{+}$	$p < .01^{+}$
Direction of Shift	None	Risky	Cautious

*Wilcoxon matched-pairs test - ordinal data.

+t-test, 1 tail.

Group discussion has no effect on zero expected value problems. However, decisions on problems with positive expected values are significantly riskier after group discussion, while decisions on negative expected value

questions are significantly more cautious after discussion. The findings are consistent with the proposition that group discussion results in decisions closer to maximizing expected value, and that discussion does not result in risk bias in the absence of uncertainty.

Tables 5, 6, and 7 compare the amounts bet by individuals on uncertain questions before and after group discussion.

TABLE 5

Comparison of Pre- and Post-Discussion Individual Risk Scores on Uncertain Problems

	All Uncertain Problems		
	Zero Expected Value	Positive Expected Value	Negative Expected Value
Mean Pre-Discussion Bet	40¢	55¢	45¢
Mean Post-Discussion Bet	48¢	81¢	24¢
Level of Significance: p=	.0379*	.0001+	.0001#
Direction of Shift	Risky	Risky	Cautious

*Wilcoxon matched-pairs test, 1 tail
+t-test, 1 tail
#t-test, 2 tail

TABLE 6

Comparison of Pre- and Post-Discussion Individual Risk Scores on Uncertain Problems

Problems Involving Small Uncertainty	Zero Expected Value	Positive Expected Value	Negative Expected Value
Mean Pre-Discussion Bet	41¢	58¢	47¢
Mean Post-Discussion Bet	52¢	80¢	23¢
Level of Significance: p=	.0315*	.0001+	.0001#
Direction of Shift	Risky	Risky	Cautious

*Wilcoxon matched-pairs test, 1 tail

+t-test, 1 tail

#t-test, 2 tail

TABLE 7

Comparison of Pre- and Post-Discussion Individual Risk Scores on Uncertain Problems

Problems Involving Large Uncertainty	Zero Expected Value	Positive Expected Value	Negative Expected Value
Mean Pre-Discussion Bet	39¢	52¢	44¢
Mean Post-Discussion Bet	41¢	81¢	24¢
Level of Significance: p=	.2931*	.0001+	.0001#
Direction of Shift	Risky	Risky	Cautious

*Wilcoxon matched-pairs test, 1 tail

+t-test, 1 tail

#t-test, 2 tail

Risky shifts are correctly predicted for the zero and positive expected value problems. The increase in risk from pre- to post-discussion decisions on zero expected value problems can be attributed to the risk bias of group discussion under conditions of uncertainty. The much larger increase in risk on the positive expected value problems is attributed to this risk bias plus the clarification of maximum expected value.

Since our model predicts an opposition of forces in the negative expected value-uncertainty case, the significantly cautious shift shown in Tables 5, 6 and 7 for that class of problem is of itself of little utility in evaluating the model. But let us assume that the cautious shift indicates that the force tending to maximize expected value was stronger than the risk bias due to reduction of uncertainty. Such an assumption leads to the proposition that if the size of the negative expected value were reduced, the tendency to maximize expected value would become weaker relative to the risk bias of uncertainty. We would expect less cautious shift on a pure risk question, and a riskier shift on uncertain questions.

Table 8 presents the results of an experiment carried out on 40 comparable individuals in 9 groups. The problems were similar to the negative expected value problems described earlier, except that the expected value for each alternative in all problems was -10 percent of the stake, compared with -25 percent of the stake for the group reported earlier.

TABLE 8

Comparison of Pre- and Post-Discussion Individual Risk Scores
Expected Value = -10 Percent

	Pure Risk Problems	Uncertain Problems
Mean Pre-Discussion Bet	57¢	56¢
Mean Post-Discussion Bet	56¢	61¢
Level of Significance by T-test: p(1-tail) =	.4100	.01
Direction of Shift	None	Risky

These results are consistent with expectations. When the expected value of the problems is less negative, the force tending to maximize expected value in group discussion is relatively less potent. On the pure risk problems with smaller negative expected value there is much less cautious shift. On the uncertain problems with smaller negative expected value, the risk bias becomes predominant, resulting in a risky shift from pre- to post-discussion decisions.

CONCLUSIONS

The results of these experiments confirm the hypothesis that group discussion enhances prior expected value. They also confirm the hypothesis that group discussion results in a risk bias effect, under conditions of uncertainty. The gambling instruments used here lend themselves particularly well to analysis of the interaction effects of the two proposed forces at work in group decision processes.

We predict and to some extent explain. However, we do not explain the risk bias after discussion of decisions involving uncertainty. Is this a basic feature of human cognitive function?

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